# Selected Aspects of the Numerical Modeling of the Short Span Thin-Walled Beams

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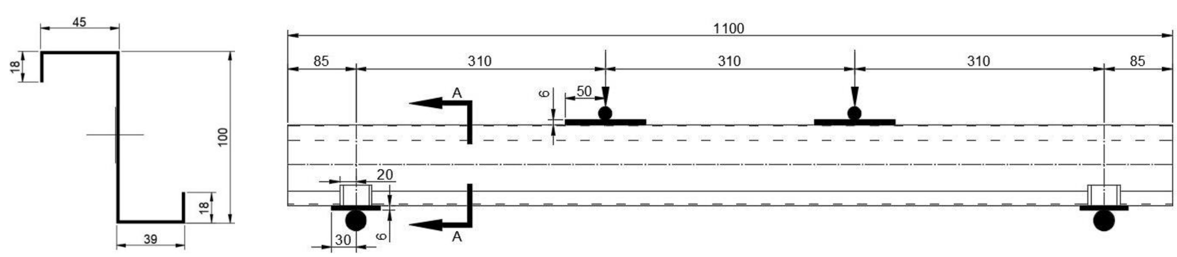
**Abstract.** This paper concentrates on selected aspects of numerical modeling of a short span thin-walled beams. The performed numerical simulations cover different types of finite elements (shell or solid finite elements) and different mesh sizes. Moreover the shape and magnitude of an initial geometrical imperfection is also investigated. The numerical analysis were made with the Newton-Raphson procedure with geometrical and material nonlinearity. The numerical results were compared with the laboratory four point bending test of a thin-walled beam. Furthermore, some guidelines for numerical simulations of a short span thin-walled beams in bending were proposed by authors.

## PROBLEM FORMULATION

The aspects of numerical modeling of thin-walled elements have been widely discussed in subject literature. For example a broad overview of computational models which refers to elastic buckling and nonlinear collapse was presented by Schafer et. al 2010. Moreover in this paper the importance of imperfections, residual stresses, material models, boundary conditions and element choice in numerical modeling of thin-walled elements has been also addressed. In turn, Jachimowicz et al. 2008 presented the Finite Elements (FE) simulation results of thin-walled beams with rivet connections in the tension zone of the cross section. Similar problem was addressed by Pařenica et al. 2017 where, the accuracy of the numerical modeling of the connection between the thin-walled element and supports was investigated.

The main aim of the paper is the convergence analysis of numerical models of short span thin-walled beams, which usually fail due to the local buckling coupled with plastic deformation. The term "short beams" is used for beams which slenderness meet the following condition $L/i_{min} < 100$. The numerical simulations were preceded by laboratory four point bending tests of Z cross section thin-walled beams, see Fig. 1. For the purpose of FE simulations, it was assumed that the material of the thin-walled element is elastic ($E = 198.7$ GPa, $\nu = 0.3$), homogeneous and isotropic. The set of parameters included in the convergence analyses is presented in Table 1.




(a) (b)

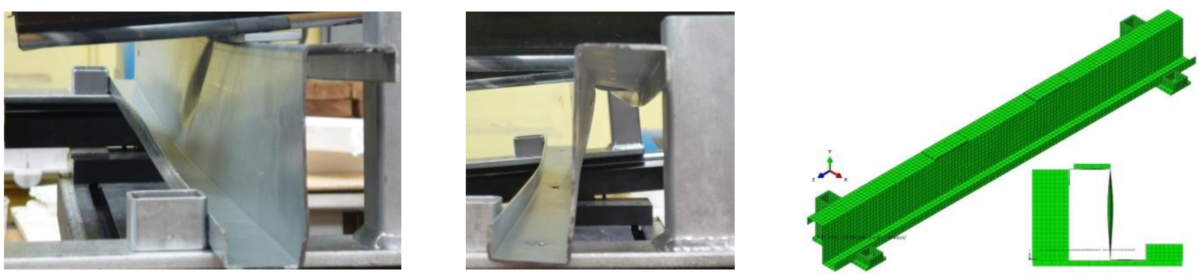
**FIGURE 1.** Four point bending test: a) dimensions of a Z cross section, b) static scheme of a four point bending test

**TABLE 1.** *The set of the parameters included in convergence analysis*

| Task | Type of the FE | Name of the FE | Mesh size [mm] | Initial geometrical imperfection | |
|---|---|---|---|---|---|
| | | | | Mode of eigenvalue | Scaling factor |
| Z-01 | shell | S4 | 2 / 5/ 10 / 15 / 20 | four modes | 1 / 2/ 4/ 8 |
| Z-02 | | S4R | 2 / 5/ 10 / 15 / 20 | two modes | 1 / 4 |
| Z-03 | | S8R | 2 / 5/ 10 / 15 / 20 | two modes | 1 / 4 |
| Z-04 | brick (solid) | C3D8 | 2 / 5/ 10 / 15 / 20 | one mode | 1 / 4 |
| Z-05 | | C3D8R | 2 / 5/ 10 / 15 / 20 | one mode | 1 / 4 |
| Z-06 | | C3D20 | 2 / 5/ 10 / 15 / 20 | one mode | 1 / 4 |
| Z-07 | | C3D20R | 2 / 5/ 10 / 15 / 20 | one mode | 1 / 4 |
| Z-08 | tetrahedron (solid) | C3D4 | 2 / 5/ 10 / 15 / 20 | one mode | 1 / 4 |

The convergence analysis of the numerical model of the short span thin-walled beam comprises not only the mesh size and the type of a finite element (shell vs. solid) but also the type of a shape function (linear vs. quadratic), the number of nodes (4, 8, 20) and the number of integration points. All finite element analyses were carried out in Abaqus CEA program. In order to obtain the nonlinear static response, the Newton-Raphson procedure was implemented. The initial geometrical imperfections were obtained from linear buckling analysis (LBA) by an arbitrary scaling of arbitrary selected buckling modes. The method of allowing for geometrical imperfection in the designing of the thin-walled beams was discussed by Dubina et al. 2001. The local buckling of a thin-walled element is depicted in Fig. 2a and 2b, while in Fig. 2c the shape of scaled buckling mode applied in the analysis is presented.

The results of convergence analysis of a numerical models of short span thin-walled beams will be presented at the conference and in the full version of the conference article.



(a) (b) (c)

**FIGURE 2.** The four point bending test of a thin-walled beam of a Z cross section: a) isometric view of a local bucking of a thin-walled beam, b) cross section view from laboratory, c) applied and scaled buckling mode.

## ACKNOWLEDGMENTS

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